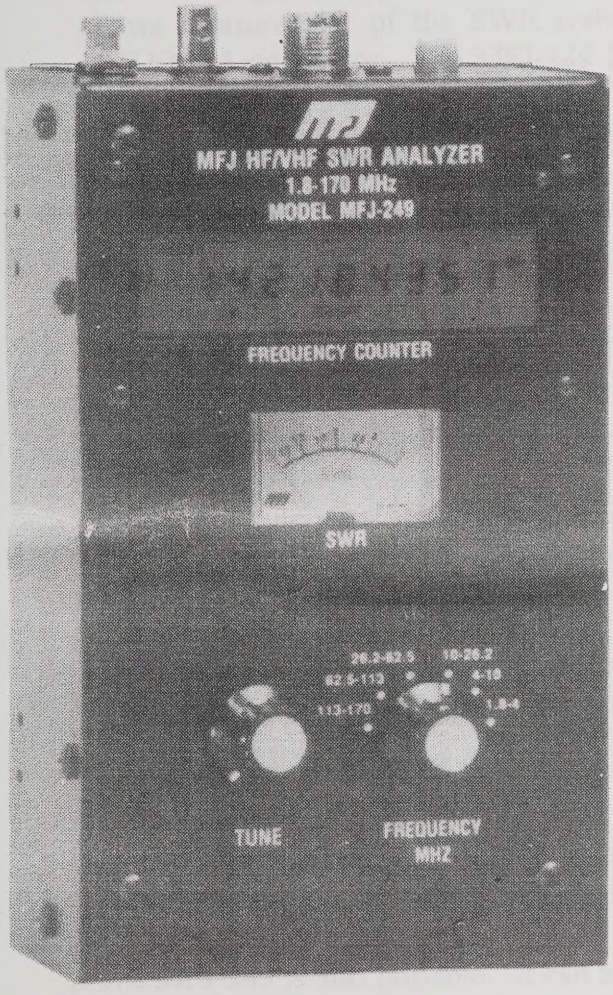
MFJ HF/VHF SWR ANALYZER

Model MFJ-249



INSTRUCTION MANUAL

READ ALL INSTRUCTIONS BEFORE OPERATING EQUIPMENT.

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VERSION 2

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MFJ-249 HF/VHF SWR Analyzer

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INTRODUCTION

The MFJ-249 SWR Analyzer is an easy to operate, versatile test instrument for analyzing nearly any 50 ohm RF system on frequencies between 1.8 and 170 MHz. In addition the MFJ-249 can be used as signal source and as an accurate frequency counter.

The MFJ-249 combines four basic circuits; a wide range oscillator, a frequency counter, a 50 ohm RF bridge, and a calibrated bridge unbalance indicator. This combination of circuits allows measurement of the SWR (referenced to 50 ohms) of any load connected to the ANTENNA connector. The MFJ-249 FREQUENCY switch selects the following frequency ranges:

1.8	-	4	MHz
4	-	10	MHz
10	-	26.2	MHz
26.2	-	62.5	MHz
62.5	-	113	MHz
113	-	170	MHz

The MFJ-249 can be used to adjust or measure the following:

Antennas:	SWR, resonant frequency, bandwidth, efficiency
Antenna tuners:	SWR, frequency
Amplifiers:	Input and output networks
Coaxial transmission lines:	SWR, velocity factor, losses, resonance
Balanced transmission lines:	Impedance, velocity factor, resonance
Matching or tuning stubs:	SWR, resonant frequency, bandwidth
Traps:	Resonant frequency
Tuned Circuits:	Resonant frequency
Small capacitors:	Value
RF chokes and inductors:	Self resonance, series resonance, value
Transmitters and oscillators:	Frequency

The MFJ-249 is also portable. It can be used with either an external low voltage supply, such the MFJ-1312B AC adapter or with internal AA battery packs.

Warning: Please read this manual thoroughly before using this instrument. Failure to follow the operating instructions may cause false readings or even damage this unit.

POWERING THE MFJ-249

The MFJ-249 requires between 8 and 18 volts for proper operation. Any power supply used with the MFJ-249 must be capable of supplying 200mA of current. An optional power supply, the MFJ-1312B, is available from MFJ for $12.95.

The MFJ-249 has a standard 2.1 mm female receptacle on the top right edge of the case. This jack is labeled "12VDC" and has the word "POWER" near it. A pictorial polarity marking appears on the case near the power jack. The outside conductor of the plug must connect to the negative supply voltage and the center conductor of the plug must connect to the positive voltage. The internal battery pack is automatically disconnected when an external power plug is inserted in this jack.

SWR measurement will be inaccurate when the supply voltage falls below 7 volts. To avoid false readings this unit has a low battery warning indication that will appear on the counter display if the supply voltage drops below acceptable levels.

Warning: Never apply AC, unfiltered or incorrectly polarized DC to this jack. Peak voltage must never exceed 18 volts.

BATTERY INSTALLATION

If batteries are used, they must be installed by removing the 8 phillips head screws on each side of the case. The eight batteries fit in two separate battery holders with the positive terminal of the batteries positioned toward the round fixed connection, and the negative terminals toward the springs of the battery holder.

The battery case has two external terminals that connect to a "pigtail" that has two terminals on it. This connector looks like the type used for 9 volt transistor radio batteries and connects in the same way. ***Do not attempt to use 9 volt batteries with this unit.*** After the batteries are installed in the plastic holders and the connections are made to the battery packs, the battery holders can be slid directly into the chrome retaining clips on the cover.

MFJ recommends the use of ALKALINE AA (or rechargeable nicad) cells to reduce the risk of equipment damage from battery leakage. Avoid leaving any batteries in this unit during periods of extended storage. Remove weak batteries immediately!

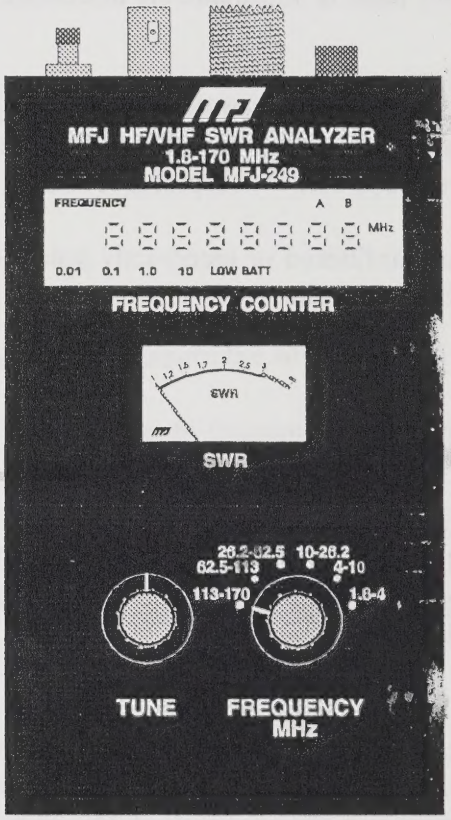
Carefully check the following:

* The battery packs are positioned so that they do not interfere with any internal parts of the MFJ-249.
* The leads are positioned to reach with the cover in the original position.
* The wires are not pinched between the cover and the chassis

OPERATION OF THE MFJ-249

After the MFJ-249 is connected to a proper power source the red on-off button can be depressed to apply power. When pressed the red button should lock into position.

Upon initial power up with no load connected, the frequency counter should display some digits, the red LED in the upper right hand corner of the unit should blink very fast, and the meter should read near full scale.



SWR and the MFJ-249

Some understanding of transmission line and antenna behavior is necessary in order to use the MFJ-249 properly. For a thorough explanation the ARRL Handbooks or other detailed textbooks can be used for reference.

SWR is the ratio of a load impedance to source impedance. Since nearly all feedlines and radio equipment used in amateur service are 50 ohms, this instrument is designed to measure the system SWR normalized to 50 ohms. For example a 150 ohm load placed across the "ANTENNA" connector will give an SWR reading of 3:1 .

The MFJ-249 measures the actual SWR. The load must be 50 ohms of pure resistance for a meter reading of 1:1 . The common misconception that 25 ohms of reactance and 25 ohms of

resistance in a load will give a 1:1 SWR is absolutely untrue. The actual SWR in this condition will be measured as 2.6:1 . The MFJ-249 is not "fooled" by mixtures of reactive and resistive loads.

Another common misconception is that changing a feedlines length will change SWR. If the impedance of a feedline is 50 ohms and the load impedance is 25 ohms the SWR will remain 2:1 as the feedline length changes. ***If line loss is low*** it is perfectly acceptable to make SWR measurements at the transmitter end of the feedline. The feedline does not have to be any particular length. However, as line loss increases, and as SWR increases, more error is introduced into the SWR reading. The error causes the measured SWR reading to appear ***better*** than the actual SWR at the antenna. Refer to the section on estimating the line loss on page 10.

If changing feedline length changes the SWR reading one or more of the following must be true:

the feedline is not 50 ohms,
the bridge is not set to measure 50 ohms,
the line losses are significant,
the feedline is acting like part of the antenna system and radiating RF.

Feedlines with very low losses, such as air insulated transmission lines, will not have much loss even when operating at extremely high SWRs. High loss cables, such as small polyethylene dielectric cables like RG-58, will rapidly lose efficiency as the SWR is increased. With high loss or long feedlines it is very important to maintain a low SWR over the entire length of the feedline.

Any SWR adjustments have to be made at the antenna, since any adjustments at the transmitter end of the feedline can not affect the losses, nor the efficiency of the antenna system.

Measuring SWR

The MFJ-249 will measure the impedance ratio (SWR) of any load referenced to 50 ohms. The SWR can be measured on any frequency from 1.8 to 170 MHz. No other devices are required.

The "ANTENNA" connector (SO-239 type) on the top of the MFJ-249 provides the SWR bridge output connection. To measure SWR, this connector must be connected to the load or device under test.

Warning: Never apply power to the "ANTENNA" connector.

To measure the SWR of a 50 ohm coaxial line simply connect the line to the "ANTENNA" connector. The counter input should be set to "A". Press the "Input" button until the "A" appears on counter display.

To measure the SWR on a predetermined frequency adjust the "TUNE" and "FREQUENCY" knobs until the counter displays the desired frequency. Read the SWR from the "SWR" meter. To find the lowest SWR adjust the frequency until the SWR meter reaches the lowest reading. Read the frequency of the lowest SWR directly from the counter display.

Note: The internal oscillator of the MFJ-249 will not produce an entirely stable reading on the frequency display due to short term drift in the oscillator. This drift is normal and does not affect the accuracy, results or usefulness of this instrument since a null will even be maintained on the highest Q (narrow bandwidth) antennas or loads.

It is perfectly acceptable to ignore decimal place readings more than two places to the right of the decimal point in the counter (ten's of kilohertz) above 15 MHz and three places to the right of the decimal point (kilohertz) below 15 MHz.

Frequency Counter

The frequency counter used in the MFJ-249 will typically measure frequencies between a few hertz and 200 MHz. The frequency counter is designed to accept TTL input voltage levels but will respond to voltages as low as a few hundred millivolts. The counter function is accurate to 1 part per million at room temperature.

To use the frequency counter turn the power "ON" and press the "INPUT" button on the top panel until a "B" appears in the upper right corner of the counter display. The BNC jack is now selected for input to the counter.

The sample time period is selected by momentarily pressing the "GATE" button near the upper left corner of the top panel. The counter displays the average frequency over the sample time period. The red LED in the upper right corner of the front panel flashes when the count cycle is complete and the display is updated. The sample time is displayed in the lower left corner of the counter display. At power up, the sample time period normalizes at .01 seconds. Additional count periods of 0.1, 1.0, and 10 seconds can also be selected.

Connect the signal to be counted to the BNC type jack labeled "FREQUENCY COUNTER INPUT".

Warning: The frequency counter has a CMOS input device that can be easily damaged. To avoid damage to the counter while using the "FREQUENCY COUNTER INPUT" jack the user must observe the following precautions: ***NEVER*** **exceed 5 volts peak input.** ***NEVER*** **apply an input signal with the power switch off.**

ADJUSTING SIMPLE ANTENNAS

Most antennas are adjusted by varying the length of the elements. Most home made antennas are simple verticals or dipoles that are easily adjusted.

Dipoles

Since a dipole is a balanced antenna, it is a good idea to put a balun at the feedpoint. The balun can be as simple as several turns of coax several inches in diameter, or a complicated affair with many windings on a ferromagnetic core.

The height of the dipole, as well as it's surroundings, influence the feedpoint impedance and the line SWR. Typical heights result in SWRs below 1.5 to one on most dipoles.

In general, the only adjustment on a dipole is the length of the antenna. If the antenna is too long it will resonate too low in frequency, and if it is too short it will resonate too high.

Verticals

Verticals are usually unbalanced antennas. Most antenna manufacturers down play the importance of good radial systems with grounded verticals. If you have a good ground system the SWR of a quarter wave vertical can be nearly 2 to one. The SWR generally gets BETTER as the ground system, and performance, get worse.

Verticals are tuned like dipoles, lengthening the element moves the frequency lower, and shortening the element moves the frequency higher.

Tuning an Antenna

Tuning basic antennas fed with 50 ohm coaxial cable can be accomplished with the following steps:

1 Connect the feedline to the MFJ-249.
2 Adjust the MFJ-249 until the SWR reaches the lowest reading.
3 Read the frequency display.
4 Divide the measured frequency by the desired frequency.
5 Multiply the present antenna length by the result of step 4. This is the new length needed.

Note: This method will not work on loaded or electrically shortened antennas. They must be tuned by adjusting and re-testing until the proper frequency is obtained.

Measuring the Feedpoint Resistance of Antennas

The feedpoint resistance of a low impedance (10-100 ohm) resonant HF antenna or load can be measured with the MFJ-249. A low value non-inductive potentiometer (250 ohms) and a conventional ohm meter can be used to make these measurements.

1 Connect the MFJ-249 directly across the terminals of the unknown impedance. If the load is unbalanced be sure that the ground is connected to the SO-239 "ANTENNA" connectors ground.
2 Adjust the MFJ-249 until the SWR reads the lowest value.
3 If the SWR is not unity (1:1) place the potentiometer in parallel with the load. Adjust the potentiometer until the SWR is as good as possible.
4 If the SWR only becomes worse go to step 7.
5 If the SWR reached unity remove the potentiometer and measure it's resistance.
6 The resistance of the load is found by using the formula below.

$$R_A = \frac{50R_P}{R_P - 50}$$

R_A = Antenna resistance

R_P = Potentiometer resistance

7 If the earlier steps did not work put the potentiometer in series with the center pin (ungrounded terminal) of the SO-239 "ANTENNA" connector.
8 Adjust the value of the potentiometer until the SWR is unity (1:1).
9 Remove the potentiometer and measure the resistance of the setting used in step 8. Subtract this value from 50 to determine the load resistance.

TESTING AND TUNING STUBS AND TRANSMISSION LINES

The proper length of quarter and half wave stubs or transmission lines can be found with this unit and a 50Ω carbon resistor. Accurate measurements can be made with any type of coaxial or two wire line. The line does ***not*** have to be 50 ohms.

The stub to be tested should be attached with a 50Ω noninductive resistor in series to the center conductor of the "ANTENNA" connector with a coaxial line. The shield should be grounded to the connector shell. For two wire lines the 50Ω resistor connects in series between the ground shell of the PL-259 and one conductor. The other conductor of the balanced line connects directly to the center pin of the connector.

Coaxial lines can lay in a pile or coil on the floor, two wire lines ***must*** be suspended in a straight line a few feet away from metallic objects or ground. The lines must be ***open circuited*** at the far end ***for odd multiples*** of 1/4 wave stubs (i.e. 1/4, 3/4, 1-1/4, etc.) and ***short circuited for half wave stub multiples*** (like 1, 1-1/2, etc.)

Connect the PL-259 to the "ANTENNA" connector of the MFJ-249 and adjust the line or stub by the following method. For critical stubs you may want to **gradually** trim the stub to frequency.

1 Determine the desired frequency and theoretical length of the line or stub.
2 Cut the stub slightly longer than necessary.
3 Measure the frequency of the lowest SWR. It should be just below the desired frequency.
4 Divide the measured frequency by the desired frequency.
5 Multiply the result by the length of the stub. This is the necessary stub length.
6 Cut the stub to the calculated length and confirm that it has the lowest SWR near the desired frequency.

Velocity Factor of Transmission Lines

The MFJ-249 can accurately determine the velocity factor of any impedance transmission line. Measure the velocity factor with the following procedure:

1. Disconnect both ends of the transmission line and measure the physical length of the line in feet.
2. Set up the line to measure 1/4 stubs as in the section on Testing and Tuning Stubs, page 8.
3. Find the ***lowest*** frequency across all the bands at which the lowest SWR occurs. The dip should occur slightly below the 1/4 wavelength frequency.
4. Read the frequency from the frequency counter display. This is the 1/4 resonant wavelength frequency of your transmission line. Note that you will get low SWR reading at all odd multiples of 1/4 wavelength.
   Example: On a 27 foot line the measured frequency was 7.3MHz.
5. Divide 246 by the measured frequency. This gives you the free space 1/4 wavelength in feet.
   Example: 246 divided by a dip frequency of 7.3 MHz is 33.7 feet, the free space 1/4 wavelength
6. Divide the physical measured length of the feedline in feet by the free space 1/4 wavelength calculated in number 5.
   Example: 27 feet (physical length) divided by 33.7 feet (calculated length) equals .80 . The velocity factor is .80 or 80%.

$$\text{Free space } 1/4 \text{ wavelength} = \frac{246}{\text{Low SWR frequency}}$$

$$\text{Velocity Factor} = \frac{\text{Free space } 1/4 \text{ wavelength}}{\text{Actual feedline length}}$$

Impedance of Transmission Lines

The impedance of transmission lines between 15 and 150 ohms can be measured with the MFJ-249, a 250 ohm potentiometer, and an ohm meter. Lines of higher impedance can be measured with a higher resistance potentiometer if a broad band transformer is used (see the section on testing transformers) to transform the line impedance to approximately 50 ohms.

1 Measure the 1/4 wavelength frequency of the transmission line to be tested as in Testing and Tuning Stubs on page 8.
2 Terminate the far end of the transmission line with a non-inductive 250 ohm potentiometer.
3 Connect the transmission line to the MFJ-249 "ANTENNA" connector and set the analyzer to the 1/4 wave frequency.
4 Observe the SWR as you vary the "TUNE" from end to end of the "FREQUENCY" range selected.
5 Adjust the potentiometer until the SWR reading varies as little as possible, over the "TUNE" range. Note that the ***value*** of the SWR is not important. Only the ***change*** in SWR as the frequency is varied is important.
6 The value of the potentiometer will correspond closely to the line impedance.

Estimating transmission line loss

The loss of 50 ohm feedlines (between 3 and 10 dB) can be measured with the MFJ-249. It is a simple matter to find the loss at a known frequency and then estimate the loss at a lower frequency.

To measure feedline loss:

1. Connect the feedline to the MFJ-249 "ANTENNA" connector.
2. The far end of the feedline is either left unconnected or terminated with a direct short.
3. Adjust the MFJ-249 frequency to the frequency desired and observe the "SWR" meter.
4. If the SWR is in the red area of the scale the loss is less than 3 dB. Increase the frequency until the "SWR" meter reads 3:1. This is the 3dB loss frequency.
5. If the SWR on the operating frequency is in the black area of the "SWR" meter, pick the closest SWR point and estimate the loss from the chart below.

SWR	LOSS
3.0 : 1	3.0 dB
2.5 : 1	3.6 dB
2.0 : 1	4.7 dB
1.7 : 1	5.8 dB
1.5 : 1	6.9 dB
1.2 : 1	10.3 dB

You can estimate the approximate loss at the operating frequency by remembering that the feedline loss in dB is reduced by 70 % at half the frequency, and increased by 140 % at twice the frequency you measured. This method is reasonably accurate if the loss is distributed along the feedline and not confined to one bad area.

For example, assume an operating frequency of 28 MHz. You want to know what the feedline loss is at 28 MHz. At that frequency the "SWR" meters needle is in the red uncalibrated portion of the meter. Increase the measured frequency until the needle falls on a calibration mark. At 60MHZ the meter reads 3:1 SWR. Using the chart you know that the loss is 3 dB. Since 28MHz is about half of 60MHz, you can multiply 3dB by .7 which gives a loss of about 2dB at 28MHz.

ADJUSTING TUNERS

The MFJ-249 can be used to adjust tuners. Connect the MFJ-249 "ANTENNA" connector to the tuner's 50 ohm input and the desired antenna to the normal tuner output. This connection can be made with a manual RF switch to facilitate rapid changeover.

Warning: Always connect the common (rotary contact) of the switch to the tuner. The switch must connect either the MFJ-249 or the station equipment to the tuner. ***The Station Equipment Must Never Be Connected To The MFJ-249.***

1 Connect the MFJ-249 to the tuner input.
2 Turn on the MFJ-249 and adjust it to the desired frequency.
3 Adjust the tuner until the SWR becomes unity (1:1).
4 Turn off the MFJ-249 and re-connect the transmitter.

ADJUSTING AMPLIFIER MATCHING NETWORKS

The MFJ-249 can be used to test and adjust RF amplifiers or other matching networks without applying operating voltages.

The tubes and other components should be left in position and connected so that stray capacitance is unchanged. A non-inductive resistor that equals the approximate driving impedance of the tube is installed between the cathode of the tube and the chassis, or a resistor should be connected between the anode and the chassis that equals the calculated plate impedance of the tube . The appropriate network can now be adjusted.

The antenna relay (if internal) can be engaged with a small power supply so that the coax input and output connectors are tied to the networks.

Caution: The driving impedance of most amplifiers changes as the drive level is varied. Do not attempt to adjust the input network with the tube in an operating condition with the low level of RF from the MFJ-249.

TESTING RF TRANSFORMERS

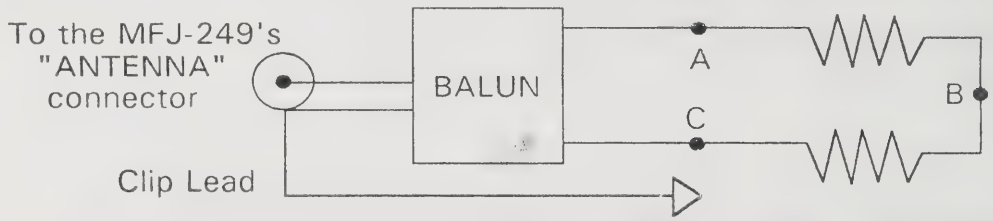
RF transformers that are designed with a 50 ohm winding can be easily and accurately tested with the MFJ-249.

The 50 ohm winding is connected through a short 50 ohm cable to the "ANTENNA" connector on the MFJ-249. The other winding(s) of the transformer is then terminated with a low inductance resistor that is equal to the windings impedance. The MFJ-249 can then be swept through the desired transformer frequency range. The SWR and bandwidth of the RF transformer can be measured.

Testing Baluns

Baluns can be tested by connecting the 50 ohm unbalanced side to the MFJ-249 "ANTENNA" connector. The balun must be terminated with two equal value load resistors in series. The resistor combination must have resistance total that is equal to the balun impedance. A pair of 100 ohm carbon resistors must be used to test the 200 ohm secondary of a 4:1 balun (50 ohm input).

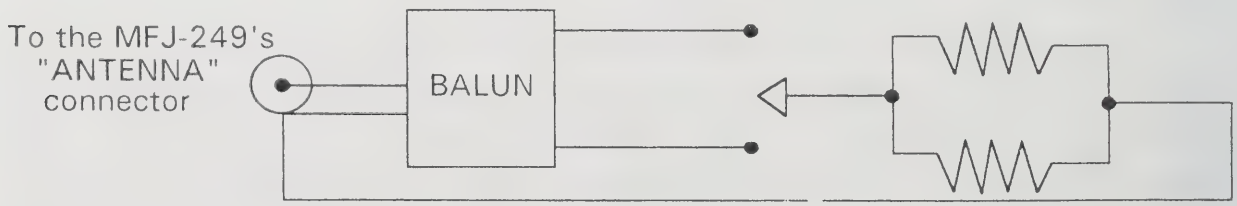
The SWR is measured by moving a jumper wire from point "A" through point "C".



A properly designed current balun, the type that is the most effective and usually handles the most power, should show a low SWR over the entire operating range of the balun with the clip lead in any of the three positions.

A well designed voltage balun should show a low SWR over the entire operating range when the clip lead is in position "B". It will show a poor SWR when the clip lead is in position "A" and "C".

A voltage balun should also be tested by disconnecting the outer connections of the two resistors and connecting each resistor in parallel. If the balun is operating properly the SWR will be very low with the resistors connected from either output terminal to ground.



MEASURING INDUCTANCE AND CAPACITANCE

To measure capacitance or inductance you will need some standard value capacitors and inductors. These should be collected and tested for accuracy. MFJ suggests the following sets of values:
Inductors: 330µH, 56 µH, 5.6 µH, .47 µH
Capacitors: 10 pF, 150 pF, 1000 pF, 3300 pF
Readings will be the most accurate if the standard test values used are between 0.5 µH to 500 µH to measure capacitance or 10 pF and 5000 pF to measure inductance.

Take a component of unknown value and connect it in series with a standard component to make a series LC circuit. Attach the series LC circuit to the "ANTENNA" connector in series with a 50 Ω resistor.

Measure capacitance.

1. Connect an unknown capacitor in parallel with the highest value standard inductor.
2. Connect the LC circuit to ANTENNA connector with a 50 Ω resistor in series.
3. Adjust the tune knob through the bands until you get the lowest SWR. If you do not get a deep meter deflection change to the next inductor with a lower value and try again. Continue the process until you obtain low SWR.
4. Solve this equation using F as the resonant frequency as L as the inductance of the standard inductor,

$$C(pF) = \frac{1}{.00003948F^2L}$$

F = MHz L = µH

Measure inductance.

1. Connect an unknown inductor with the highest value standard capacitor in parallel.
2. Connect the LC circuit to "ANTENNA" connector with a 50 Ω resistor in series.
3. Adjust the tune knob through the bands until you get the lowest SWR. If you do not get a deep meter deflection change to the next smaller value standard capacitor and try again. Repeat the process until you get low SWR.
4. Solve this equation using F as the resonant frequency and C as the capacitance of the standard capacitor.

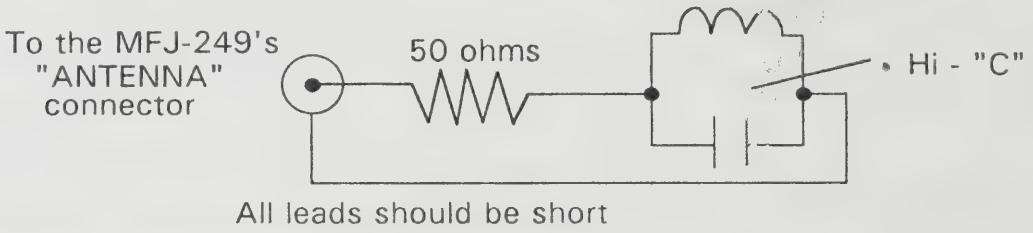
$$L(\mu H) = \frac{1}{.00003948F^2C}$$

F = MHz C = pF

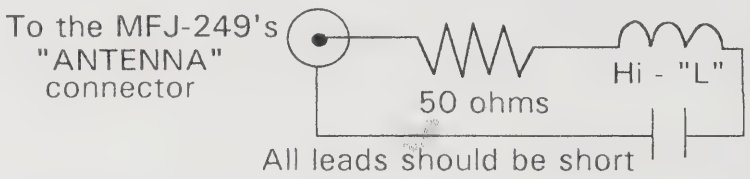
RESONANT FREQUENCY OF TUNED CIRCUITS

The MFJ-249 can be used to measure the resonant frequency of tuned circuits by two methods. The first method involves placing a 50 ohm resistor in series with the MFJ-249 "ANTENNA" connector. The MFJ-249 connects through the resistor to the parallel tuned circuit. This circuit is for high capacitance values.

Tune the MFJ-249's frequency until the "SWR" meter reaches the highest SWR. This is the resonant frequency of the load.

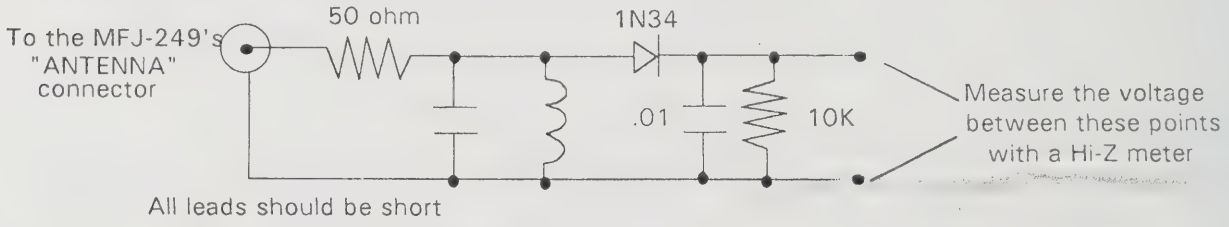


For high inductance values a series LC circuit should be used to measure resonant frequency. The inductor and capacitor should be connected in series through a 50Ω low inductance carbon resistor across the "ANTENNA" connector on the MFJ-249.



Tune the MFJ-249's frequency until the "SWR" meter reaches the lowest SWR. This is the resonant frequency of the load.

An external diode detector and volt meter can also be used to measure the resonant frequency of circuits. The maximum meter reading occurs at the resonant frequency.

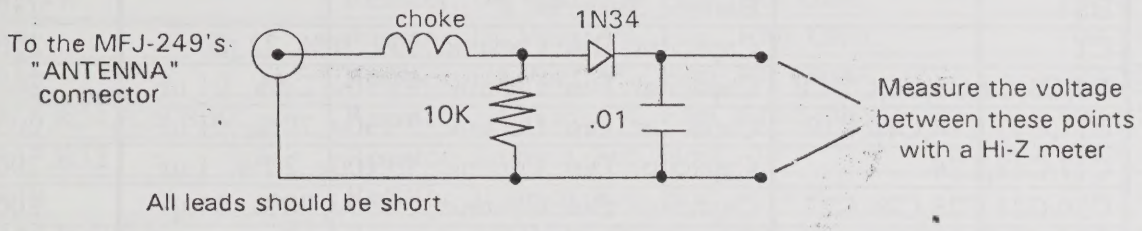


A second method of determining the resonant frequency is by using a small three or four link coil to magnetically couple to a tuned circuit for testing. The coil should be wound around the inductor in the tuned circuit. This magnetically couples the MFJ-249 to the resonant circuit.

The frequency of the MFJ-249 is adjusted for a dip on the "SWR" meter. The dip occurs at the approximate resonant frequency of the tuned circuit.

Testing RF Chokes

Large RF chokes usually have frequencies where the distributed capacitance and inductance form a low impedance series resonance. The troublesome series resonance can be detected by slowly sweeping the frequency of the MFJ-249 over the operating range of the choke. Peaks in the voltage measured by the RF voltmeter will identify the low impedance series-resonant frequencies.



Refer to the section on measuring the inductance of RF chokes on page 13.

MFJ-249 PARTS LIST

Part Designator	Description	MFJ Part Number
BH1	Battery, Holder, 9-v, Vertical, #80	730-2005
BH2	Battery, Holder, 6-aa,Snap Connector	730-2362
BS1	Battery, Snap, 9v, 8"	730-3005
C1	Capacitor, Disc Ceramic, 50v, 20%, 22 pF	200-0018
C2,C3,C4,C5,C6,C7,C8	Capacitor, Disc Ceramic, 25/50v, 20%, .01 uF	200-0004
C11,C13,C14,C16,C19	Capacitor, Disc Ceramic, 25/50v, 20%, .01 uF	200-0004
C17,C18,C24	Capacitor, Disc Ceramic, 50/100v, 20%, .1 uF	200-0005
C20,C21,C25,C26,C27	Capacitor, Disc Ceramic, 25/50v, 20%, .01 uF	200-0004
C22,C23,C32,C39	Capacitor, Disc Ceramic, 25/50v, 20%, .01 uF	200-0004
C28	Capacitor, Electrolytic, Radial, 25v, 100 uF	203-0015
C29	Capacitor, Disc Ceramic, 500v, 20%, 75 pF	200-1011
C30	Capacitor, Disc Ceramic, 1 KV, 20%, 470 pF	200-2023
C31	Capacitor, Disc Ceramic, 1 KV, 20%, 33 pF	200-2016
C32	Capacitor, Electrolytic, Radial, 50v, 1 uF	203-0006
C33,C36,C10	Capacitor, Disc Ceramic, 25/50v, 20%, .01 uF	200-0004
C38	Capacitor, Electrolytic, Radial, 35v, 220 uF	203-0019
C?	Cap, Air Var, 6-200pf	204-5160
D2,D3,D4	Diode, Germanium, 1N34A	300-8001
FOR IC1	Socket, IC, Low Profile, 14 Pin	625-0031
FOR SW2	Knob, Plastic, Push-button, .350" Dia, Red	760-2140
IC1	IC, Op-amp, Quad Op-amp, 14 Pin, LM324N	311-0040
IC2	Voltage Regulator, To-220, +5 Volts, 7805t	307-1011
J1	Connector, HF, 4-hole Mount, So-239	610-2005
J1	Jack, 2.1 Mm, PCB, Dc Coaxial Jack	601-6021
J2	Connector, BNC, Chassis Mt., Female	610-1016
J2	Connector, Header, Straight, .1, .375", 3 Pos	612-0103
J3	Connector, Socket, .1, .75", Dual Row, 7 Pos	612-3307
JMP1-JMP4	Wire, Jumper, 1/4"-2"	870-5000
KN1	Knob, 1/4" Shaft, .75 X .75, PKA 50b Knob	760-0033
L1	Inductor, Var., PCM, 10 K, 4087, 66uH	402-3421
L2	Inductor, Xformer, Blue, 10-406/9441, 7.8 uH	402-3406
L3	Inductor, Xformer, Red, 10-402/9449, 1.8 uH	402-3402
L4	Inductor, MC120 W/o Case, Green, .211 uH	402-2728
L7	Hardware, PCB, Pick-up Coil, #61 Pre-wound	10-01003
M1	Meter, 1.5", 100 uA, SWR Meter	400-0035
MOD1	Counter Module, LCD	50-247-3
Q1,Q2,Q4	Transistor, Fet, To-92, Siliconix, J310	305-6310
Q3	Transistor, Fet, Switching, VN10KM	305-6005
Q5	Transistor, HF Wide Band, NPN, 2n5109	305-0017

Part Designator	Description	MFJ Part Number
R1	Resistor, 1/4 Watt, 5%, Film, 18 Ohm	100-1180
R2,R21,R22	Resistor, 1/4 Watt, 5%, Film, 1m Ohm	100-6100
R3,R8	Resistor, 1/4 Watt, 5%, Film, 100 Ohm	100-2100
R4,R7	Resistor, 1/4 Watt, 5%, Film, 10 Ohm	100-1100
R5,R6	Resistor, 1/4 Watt, 5%, Film, 1.0k Ohm	100-3100
R9	Resistor, 1/4 Watt, 5%, Film, 100k Ohm	100-5100
R10	Resistor, 1/4 Watt, 5%, Film, 39k Ohm	100-4390
R15,R24,R29,R30	Resistor, 1/4 Watt, 5%, Film, 10.0k Ohm	100-4100
R17,R32	Resistor, Trimpot, Sub. Horz., 10 K	133-4100
R18	Resistor, Trimpot, Sub. Horz., 100 K	133-5100
R26,R27,R28	Resistor, 1/8 Watt, 1%,49.9 Ohm	102-1499
R33	Resistor, 1/4 Watt, 5%, Film, 620 Ohm	100-2620
SW1	Switch, Rotary, PCB, Horiz, 2p6p	500-1565
SW2	Switch, Push-button, PC, .5 A, 125 Vac, 2p2p	504-0022
SW3	Switch, Push Button, 3 Amp, Spst(n.o.)mem	504-1003

TECHNICAL ASSISTANCE

If you have any problem with this unit first check the appropriate section of this manual. If the manual does not reference your problem or your problem is not solved by following the manual you may call MFJ toll-free at 1-800-647-TECH (8324) or FAX to 601-323-6551, or TELEX 53 4590 MFJ STKV. Outside of the continental U.S.A. 601-323-5869. You will be best served if you have your unit, manual and all information on your station handy so you can answer any questions the technicians may ask.

You can also send questions to MFJ Enterprises, INC., P.O. Box 494, Mississippi State, MS 39762. Send a complete description of your problem, an explanation of exactly how you are using your unit and a complete description of your station.

FULL 12 MONTH WARRANTY

MFJ Enterprises, Inc. warrants to the original owner of this product, if manufactured by MFJ Enterprises, Inc. and purchased from an authorized dealer or directly from MFJ Enterprises, Inc. to be free from defects in material and workmanship for a period of 12 months from date of purchase provided the following terms of this warranty are satisfied.

1. The purchaser must retain the dated proof-of-purchase (bill of sale, canceled check, credit card or money order receipt, etc.) describing the product to establish the validity of the warranty claim and submit the original of machine reproduction or such proof of purchase to MFJ Enterprises, Inc. at the time of warranty service. MFJ Enterprises, Inc. shall have the discretion to deny warranty without dated proof-of-purchase. Any evidence of alteration, erasure, of forgery shall be cause to void any and all warranty terms immediately.

2. MFJ Enterprises, Inc. agrees to repair or replace at MFJ's option without charge to the original owner any defective product provided the product is returned postage prepaid to MFJ Enterprises, Inc. with a personal check, cashiers check, or money order for $7.00 covering postage and handling.

3. MFJ Enterprises, Inc. will supply replacement parts free of charge for any MFJ product under warranty upon request. A dated proof of purchase and a $5.00 personal check, cashiers check, or money order must be provided to cover postage and handling.

4. This warranty is **NOT** void for owners who attempt to repair defective units. Technical consultation is available by calling (601) 323-5869.

5. This warranty does not apply to kits sold by or manufactured by MFJ Enterprises, Inc.

6. Wired and tested PC board products are covered by this warranty provided **only the wired and tested PC board product is returned.** Wired and tested PC boards installed in the owner's cabinet or connected to switches, jacks, or cables, etc. sent to MFJ Enterprises, Inc. will be returned at the owner's expense unrepaired.

7. Under no circumstances is MFJ Enterprises, Inc. liable for consequential damages to person or property by the use of any MFJ products.

8. **Out-of-Warranty Service:** MFJ Enterprises, Inc. will repair any out of warranty product provided the unit is shipped prepaid. All repaired units will be shipped COD to the owner. Repair charges will be added to the COD fee unless other arrangements are made.

9. This warranty is given in lieu of any other warranty expressed or implied.

10. MFJ Enterprises, Inc. reserves the right to make changes or improvements in design or manufacture without incurring any obligation to install such changes upon any of the products previously manufactured.

11. All MFJ products to be serviced in-warranty or out-of-warranty should be addressed to **MFJ Enterprises, Inc., 921A Louisville Road, Starkville, Mississippi 39759, USA** and must be accompanied by a letter describing the problem in detail along with a copy of your dated proof-of-purchase.

12. This warranty gives you specific rights, and you may also have other rights which vary from state to state.